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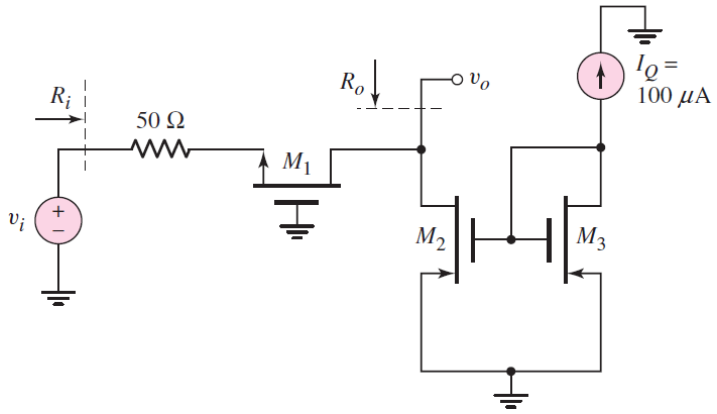
ECE322L -Homework 4 (100 points)
Assigned on Thursday, 02/20/2020-11 am
Due on Thursday, 02/27/2020-11 am

The ac equivalent circuit of a CMOS amplifier is shown below. (a) Identify the type of configuration. (b) Determine the small-signal voltage gain, the input resistance, and the output resistance.



The transistor parameters for M_1 are V_{TN}=0.5 V, k_n'=85 μA/V², $(W/L)_1$=50, λ = 0.05 V⁻¹, and for M_2 and M_3 are V_{TP}=-0.5 V, k_p'=40 mA/V², $(W/L)_{2,3}$=50 and λ =0.075 V⁻¹.

(a) Common gate

(b) $$r_{0_1} = \frac{1}{\lambda_1 I_D} = \frac{1}{(0.05V^{-1})(100\mu A)} = 200k\Omega$$

$$r_{0_2} = \frac{1}{\lambda_2 I_D} = \frac{1}{(0.075V^{-1})(100\mu A)} = 133.333k\Omega$$

$$g_{m_1} = 2\sqrt{K_n I_D} = 2\sqrt{\frac{k_n'}{2}\left(\frac{W}{L}\right)_1 I_D} = 2\sqrt{\frac{85\frac{\mu A}{V^2}}{2}(50)\,100\mu A} = 921.95\frac{\mu A}{V}$$

$$R_{in_1} = \frac{1}{g_{m_1}} = \frac{1}{921.95\frac{\mu A}{V}} = 1.0847k\Omega$$

$$V_{GS_1} = -\left(\frac{R_{in_1}}{R_{in_1} + R_{sig}}\right)V_{in} \quad \rightarrow \quad \frac{V_{GS_1}}{V_{in}} = -\left(\frac{R_{in_1}}{R_{in_1} + R_{sig}}\right)$$

$$\frac{V_{GS_1}}{V_{in}} = -\frac{1.0847k\Omega}{1.0847k\Omega + 50\Omega} = -955.94mV$$

$$A_v = -g_{m_1}\left(r_{0_1} \parallel r_{0_2}\right)\frac{V_{GS_1}}{V_{in}} = -\left(921.95\frac{\mu A}{V}\right)\left(200k\Omega \parallel 133.33k\Omega\right)\left(-955.94mV\right)$$

$$A_v = 70.506\left(\frac{V}{V}\right)$$

$$R_{in} = \frac{1}{g_m} + R_{sig} = \frac{1}{921.95\frac{\mu A}{V}} + 50\Omega = 1.1347k\Omega$$

$$R_{out} = r_{0_1} \parallel r_{0_2} = 200k\Omega \parallel 133.33k\Omega = 80k\Omega$$